

FRESHWATER MUSSELS (MOLLUSCA: PELECYPODA: UNIONIDAE) OF  
TELLICO LAKE: TWELVE YEARS AFTER IMPOUNDMENT OF  
THE LITTLE TENNESSEE RIVERPAUL W. PARMALEE<sup>1</sup>

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## ABSTRACT

A species survey of freshwater mussels (Pelecypoda: Unionidae) inhabiting Tellico Lake, Monroe and Loudon counties, Tennessee, was carried out from November 1990 to April 1991. Seventy collection stations and an additional 24 km of exposed beach were examined for unionid shells. All specimens encountered were collected and counted. Fourteen native taxa were represented. *Anodonta grandis* is the most abundant and widespread species in the lake; eight others, all silt-tolerant species, are also widely distributed with viable local populations. Based on taxa identified from aboriginal sites along the Little Tennessee River and from recent mussel surveys, 50 unionid species inhabited the river prior to its impoundment in 1979. Only 15 to 18 of these were reported still inhabiting the river in 1972; 12 years after formation of Tellico Lake, only six of those taxa have been found, while eight others previously unrecorded have invaded the lake.

## INTRODUCTION

Arising in Rabun County, Georgia, at an elevation of 1000 m, the Little Tennessee River flowed 214 km to its confluence with the Tennessee River. It once flowed freely, cascading over Precambrian and Cambrian sandstones, shale and siltstone in the Blue Ridge physiographic province between the Unaka Mountains of Georgia, North Carolina, and Tennessee to about 53 river km above its confluence with the Tennessee River. About 7 km below that point, the river widened and slowed as it entered the Ridge and Valley province of Ordovician limestone and dolomite at an elevation of just under 250 m, transforming from a montane to a lowland river. This lower 53 km of the Little Tennessee River (now Tellico Lake), from Chilhowee Dam to its confluence with the Tennessee River at Lenoir City, is the section surveyed by us for mussels. Composition of the substrate of this lower 53 km of the Little Tennessee River has been characterized as "... bedrock-boulder, boulder-cobble, sand-gravel, sand and silty sand" (Starnes, 1977: 30).

Molluscan remains recovered and identified from aboriginal habitation sites excavated along the Little Tennessee River prior to its impoundment in 1979 provide evidence of the abundance and variety of species that formerly inhabited the river. At the Toqua site (40MR6), between river km 36.8 and 37.6, Bogan (1987) identified 40 species of mussels. Many of the species represented at the

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Toqua site also were found in archaeological context at other sites such as Martin Farm (40MR20), river km 35.5 (Bogan and Bogan, 1985), and Bat Creek (40LD24) (Schroedl, 1975). In sampling the benthic fauna of the Little Tennessee River for the Tellico Project Environmental Impact Statement, Tennessee Valley Authority (TVA) biologists recorded 22 species of mussels inhabiting the river below Chilhowee Dam (TVA, 1972). Although the thoroughness of the survey is questionable as is the taxonomic allocation of certain species, and the fact that inclusion of two taxa was based on earlier collections (Ortmann, 1918), these pre-impoundment collections indicated that at least 15 to 18 species known prehistorically inhabited the river at the time the Tellico Dam gates were closed.

Impoundment of the Little Tennessee River, from the Tellico Dam at the confluence of the Little Tennessee River and the Tennessee River near Lenoir City (Loudon County) to a point approximately 0.8 km below Chilhowee Dam (Blount/Monroe counties), a distance of approximately 52.8 km, resulted in the formation of Tellico Lake (Fig. 1). The reservoir inundated approximately 5,760 ha (TVA, 1972), including 32 km of the lower Tellico River, a major tributary of the Little Tennessee River. Normal reservoir level at full summer pool is 243.9 km above Mean Sea Level (AMSL); after drawdown in November winter water levels fluctuate between 242.1 and 242.6 km AMSL. As construction of the Tellico Dam neared completion, a canal was excavated to connect the new Tellico Lake with Fort Loudoun Lake (Tennessee River), an 88 km long reservoir resulting from the construction of Fort Loudoun Dam in 1943 by the TVA. This made Tellico Lake and Fort Loudoun Lake essentially one large reservoir. The canal provided direct access for fish from Fort Loudoun Lake to Tellico Lake. As a result fish parasitized with glochidia were probably the primary source of mussel species that invaded Tellico Lake.

## METHODS

Tellico Lake, which has been established for slightly over a decade, provided an opportunity to document changes in the molluscan fauna of a river when it is converted into a reservoir. To assess the distribution and species assemblage of freshwater mussels inhabiting Tellico Lake surveys were conducted following the November drawdown, as the lowered reservoir level (ca. 2 m) resulted in extended stretches of exposed banks, shallow coves (Fig. 2), and beaches surrounding low-lying islands. County and private roads provided access to the reservoir at numerous points along both shorelines. In addition, a 12-foot john boat was used to survey islands and stretches of shoreline inaccessible by road. A minimum of 24 km of shoreline was surveyed by moving slowly parallel to the banks and beaches, searching for shell by visual observation aided by the use of binoculars. In addition to surveying exposed substrate that appeared to be suitable mussel habitat (composites of sand, fine gravel and mud), shale and red clay banks were also scrutinized but with negative results.

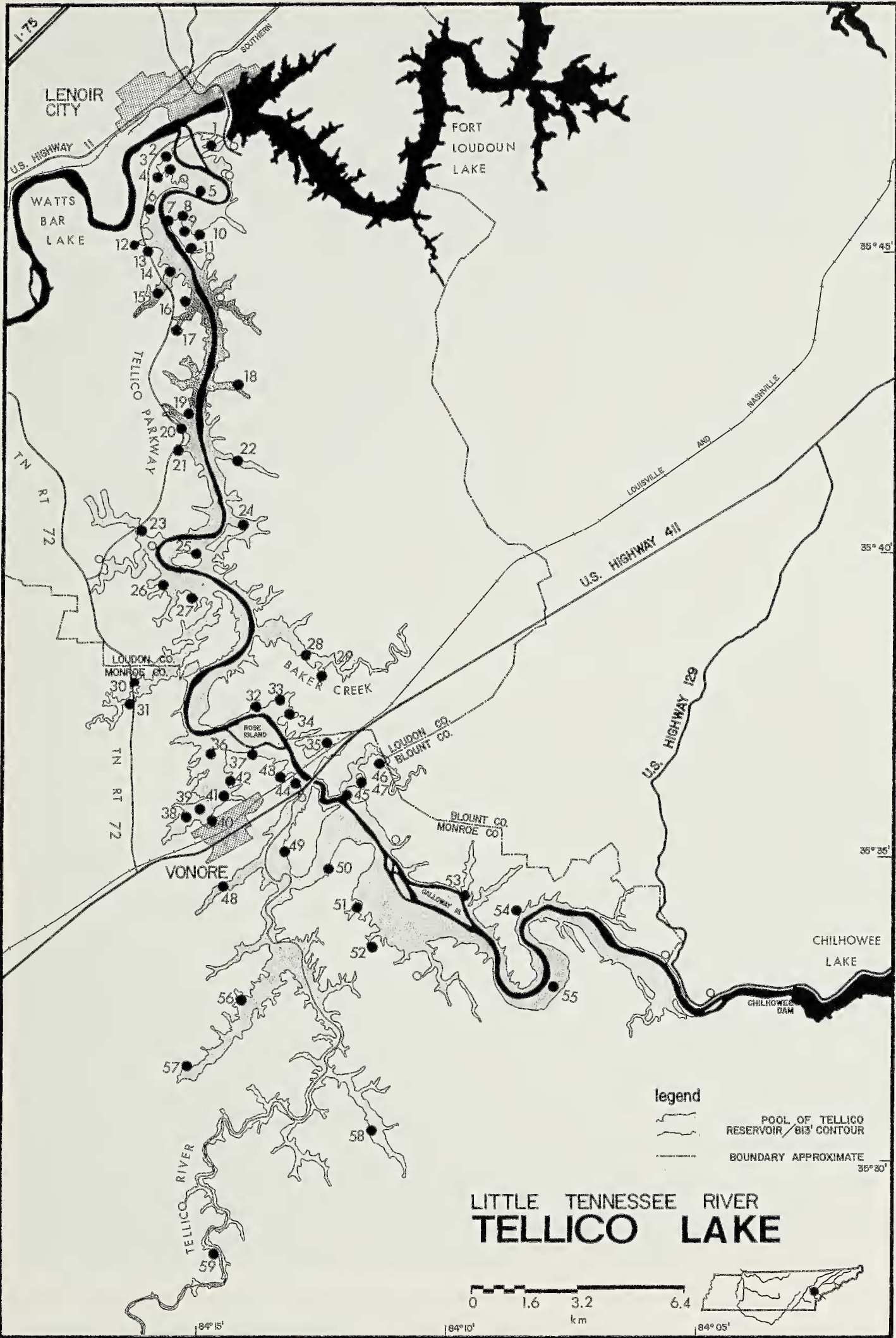
Juvenile shells of mussels inhabiting the Tennessee River reservoirs might conceivably be overlooked. However, we demonstrated by recovering 75 juveniles of *T. donaciformis*, a small species that rarely exceeds 40 mm in length, from the exposed beaches of Babe's Island (Watts Bar Lake, Tennessee River km 896.5) in under two hours, that shells of even minute individuals (<15 mm) were easily discernible. Shells were found at 59 of the 70 Tellico Lake collection stations (Table 1).

Collection stations were selected to sample the entire length of the Tellico reservoir, including the islands, embayments, coves and impounded lower stretches of numerous former tributaries of the Little Tennessee River. Shells left by muskrats, *Ondatra zibethica* (Linnaeus, 1766), at feeding stations proved to be a primary source of specimens. These aquatic rodents usually bring mussels to feeding stations such as stumps, overhanging trees, brush piles, riprap, and even silo interiors (see Fig. 2). But

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Fig. 1.—Distribution of collecting stations (solid dots = mussels present, open circles = mussels absent) in the Tellico reservoir, and relationship of original channels of the Little Tennessee and lower Tellico rivers to Tellico Lake.







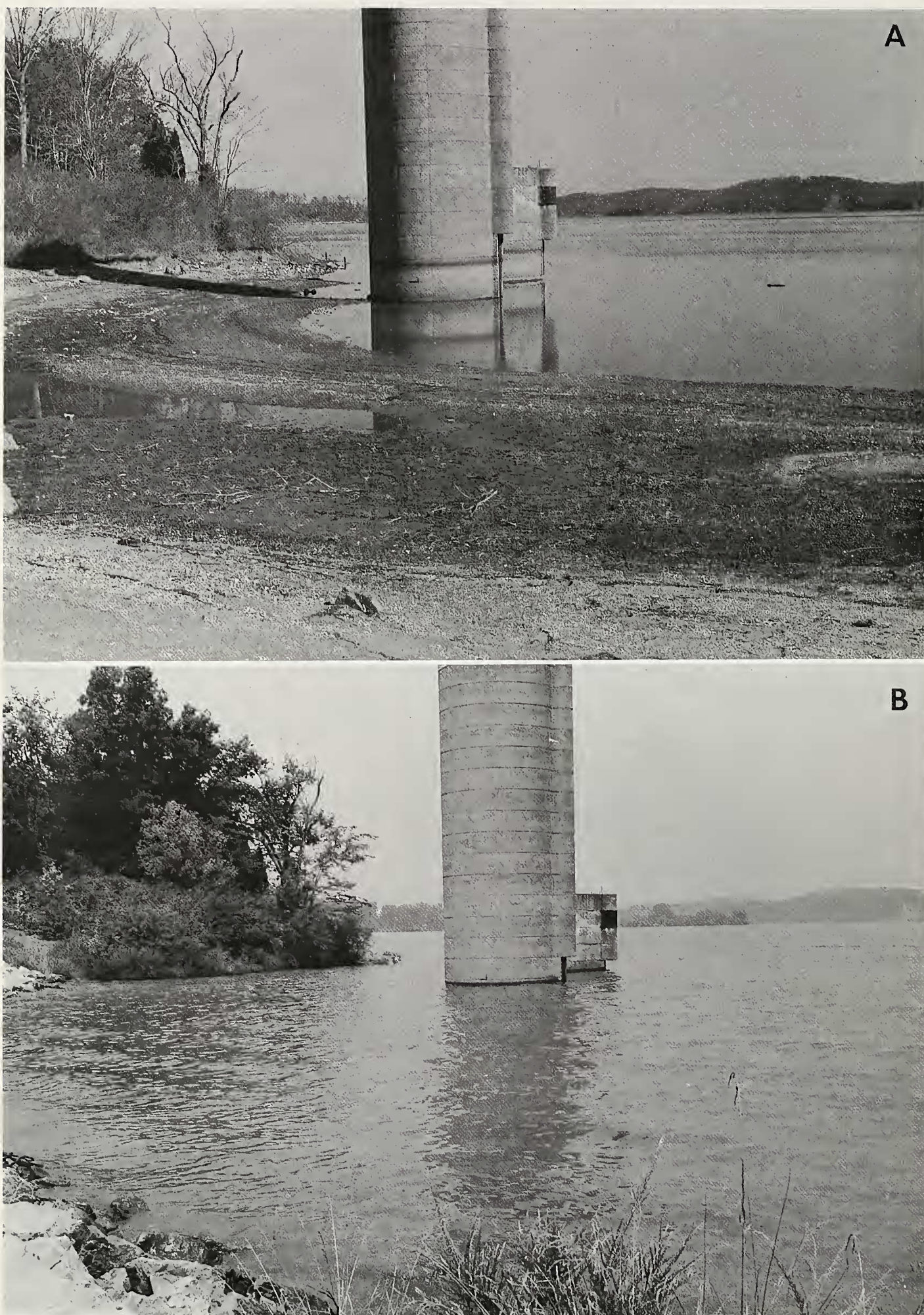


Fig. 2.—Tellico Lake, Loudoun County, Tennessee, Collection Station 6, showing exposed beach and low water level during winter drawdown (A) and summer full pool level (B).



large heavy individuals such as mature *Anodonta grandis* and *Lasmigona complanata*, retrieved as the water receded, were carried into the shallows and eaten there. Collection stations varied in size from an isolated muskrat feeding station to stretches of exposed beach. However, all shells found at each station were collected, counted and recorded. Identifications were made by comparison with specimens in the malacology collections at the Frank H. McClung Museum, University of Tennessee-Knoxville. Because of the discrepancy in the size and/or form (e.g., beach vs riprap) of collection stations, only the presence of the species identified from each is indicated (x) in Table 2.

Voucher specimens of shells obtained during this study were deposited in the Frank H. McClung Museum collections, and voucher specimens of some taxa have been deposited in the Department of Malacology, Academy of Natural Sciences of Philadelphia, and the Section of Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania. Unionid taxonomy used in this study is from Turgeon et al. (1988).

### DISCUSSION

Starnes and Bogan (1988) listed 50 unionid taxa for the Little Tennessee River. Sixteen, or 32%, are known only from the archaeological record. Species such as *Elliptio dilatata* (Rafinesque, 1820), *Pleurobema oviforme* (Conrad, 1834), *Fusconaia barnesiana* (Lea, 1838), *Fusconaia subrotunda* (Lea, 1831), *Lampsilis fasciola* Rafinesque, 1820 and *Actinonaias ligamentina* (Lamarck, 1819) inhabited numerous stretches of the river and several of its major tributaries. Favorable habitat consisted of moderate current, riffles and shallow pools and a substrate composed of silt, sand and fine to coarse gravel. Except for the Asian clam and six native unionid taxa, all other mussel species recorded for the Little Tennessee River disappeared before or shortly after impoundment.

Studies comparing the pre-impoundment molluscan fauna of a river with the fauna of the resulting reservoir (Parmalee et al., 1980; Parmalee et al., 1982) have shown that major changes take place as a result of such habitat modification. In a survey of the mussel fauna of a 17.6 km stretch of Fort Loudoun Lake, Isom (1971) found only four native species inhabiting this former section of river. Ortmann (1918) reported around 64 species from the Tennessee River in the general area surveyed by Isom. However, the species reported by Isom (1971) were the result of one day's collecting, so a more extensive survey of the reservoir may have yielded additional species. Nevertheless, the few taxa represented in the survey (Isom, 1971), and Isom's discussion of possible reasons for the absence of other expected species, have a bearing on our analysis of the mussel assemblage extant in Tellico Lake.

Three species of *Anodonta* were encountered during the survey of Tellico Lake. *Anodonta grandis*, primarily the form *A. g. corpulenta* (Cooper, 1834), was the most numerous and widespread of the three. *Anodonta imbecillis* Say, 1829 is also well established throughout Tellico Lake, but populations appear to be more localized than those of *A. grandis*, and occur primarily in shallow embayments and coves with substrates of mud (silt) and fine sand. Populations of *Anodonta suborbiculata* Say, 1831, like those of *A. imbecillis*, are localized in the same type of habitat but are more limited in distribution. Specimens of *A. suborbiculata* were encountered at only nine of 70 collection stations. With the exception of Baker Creek (Station 29), all were found in the lower stretches of the reservoir within 12.5 km of Tellico Dam.

Isom (1971) first recorded *A. corpulenta* (= *A. grandis*) and *A. imbecillis* from Fort Loudoun Lake, and first reported extensive populations of *A. grandis*, *A. suborbiculata*, and *Lasmigona complanata* (all new distribution records) in Chickamauga Reservoir (Isom, 1969). Except for one specimen of *A. imbecillis* from Savannah, Tennessee, van der Schalie (1939) reported no other species of *Ano-*



Table 1.—*Collection Station number and location on Tellico Lake, with approximate Little Tennessee River km of each. See Fig. 1.*

Collection station number and location	Approximate Little Tennessee River km
1. Tellico Dam Rec. Area	1.6
2. Saddle Dam 1 cove N	0.8
3. Rock Island, Saddle Dam 1 cove	0.8
4. Saddle Dam 1 cove S	0.8
5. Hall Bend Island	4.0
6. Silos, Tellico Parkway	5.4
7. Jackson Bend NW	4.5
8. Jackson Bend NE	5.6
9. Jackson Bend SW	4.2
10. International Harbor	3.8
11. Wyly Cemetery	6.7
12. Impounded pond at Poplar Springs	5.9
13. Poplar Springs Rec. Area	6.1
14. Island south of Poplar Springs	6.2
15. Bay north of Davis Cemetery	7.2
16. North of Davis Cemetery	8.2
17. Davis Cemetery	8.5
18. Axley Cemetery	10.9
19. Tellico Village Yacht Club	12.0
20. Tellico Village town houses	12.5
21. Tellico Village Visitors Center	13.0
22. Sinking Creek	12.5
23. Clear Creek, Tellico Parkway	17.9
24. Lotterdale Cove Rec. Area	14.9
25. Jackson Bend island	18.6
26. Russell Cemetery	18.4
27. High Top	19.0
28. Baker Creek at bridge	21.8
29. Baker Creek S of bridge	21.8
30. Cove along TN Route 72	19.0
31. Bat Creek	19.0
32. Bay just north of Rose Island	27.8
33. Rose Island bay N	28.2
34. Rose Island bay S	28.5
35. Beach North of railroad	28.8
36. Mouth of Island Creek	26.6
37. Bay W of railroad	30.1
38. Island NW of Vonore	26.6
39. Island N of Vonore	26.6
40. Vonore Beach	26.6
41. Island Creek ENE of Vonore	26.4
42. East bank of Vonore bay	26.6
43. Embayment N of railroad	30.1
44. Bay S of railroad	30.1
45. Mouth of Ninemile Creek	32.0
46. Ninemile Creek at TN Route 72	32.0
47. Ninemile Creek at marina	32.0
48. Fourmile Creek	30.4
49. Fort Loudoun State Historic Area	30.4
50. Toqua Cemetery	33.3
51. Toqua Rec. Area N	34.9
52. Toqua Rec. Area S	35.5
53. Smoky Branch Rec. Area	36.8
54. Choata Wildlife Refuge Unit	44.2
55. Tanasi Historic Site	41.6



Table 1.—*Continued.*

Collection station number and location	Approximate Little Tennessee River km
56. Notchy Creek Rec. Area	30.4
57. Notchy Creek embayment S	30.4
58. Ballplay embayment	30.4
59. Sloan Bridge	30.4

*donta* in collections (18 localities) from the lower Tennessee River between the confluence of the Hiwassee River, Meigs County, Tennessee, and Paducah, Kentucky. Impoundment of the Tennessee River and its major tributaries such as the Little Tennessee River has reduced in number or eliminated many species, brought about the colonization of shallows by others (e.g., *Anodonta*), and resulted in the establishment of species unreported prior to impoundment (Isom, 1969).

*Elliptio crassidens* was known from the Little Tennessee River prior to impoundment, and Parmalee and Klippel (1984) reported it from an unimpounded stretch of the Tellico River (Nars Ford, Tellico River km 34.4–35.2), approximately 4 km upstream from the Tellico Reservoir. In this survey only one specimen of *E. crassidens* was recovered, a juvenile ( $59.0 \times 35.5 \times 24.0$  mm) at Collection Station 6. It is doubtful whether the original population(s) of this mussel in the Little Tennessee River and the Tellico River (only five specimens recovered during numerous collecting trips in 1982 and 1983) survive. Although mature specimens of *E. crassidens* were found during TVA mussel surveys of the Chickamauga and Watts Bar reservoirs, no juveniles were found (S. A. Ahlstedt, personal communication, 1991). It is doubtful that *E. crassidens* would become established in a lake or river embayment totally lacking current. A single mature specimen of *Truncilla donaciformis* was found at Collection Station 21, and three specimens of *T. truncata* (Rafinesque, 1820), one juvenile and two adults, were found (probably taken by muskrats) at Collection Stations 4 and 20. It has been shown (Klippel and Parmalee, 1979) that *T. truncata* can develop reproductively viable populations in a lake environment. Isom (1971) collected a single specimen of *T. truncata* in Fort Loudoun Lake, but noted that it was present in the Tennessee River prior to impoundment. Starnes and Bogan (1988) did not record it as part of the unionid fauna of the Little Tennessee River.

Only three small local populations of *Toxolasma parvus* (Collection Stations 29, 30 and 56) and a single individual (Collection Station 19) were encountered during the survey. The species had not been recorded as occurring in the Little Tennessee River. Once established, *T. parvus* can become numerous in shallow, quiet embayments and coves with substrates composed of mud and silt. Such habitat conditions abound in Tellico Lake, and in time this species may become more numerous and widespread. *Lasmigona complanata*, another taxon previously unreported from the Little Tennessee River, has now become well established and is locally common and widely distributed throughout Tellico Lake. It, like all species presently occurring in the reservoir with viable populations, is silt tolerant and thrives in shallow coves and embayments.

Three species, *Potamilus ohiensis* (Rafinesque, 1820), *Potamilus alatus* (Say, 1817), and *Leptodea fragilis* (Rafinesque, 1820) were part of the Little Tennessee River unionid assemblage (Starnes and Bogan, 1988), but their former relative abundance is unknown. Of the three, *P. ohiensis* is the most common and widely











Table 3.—Relative abundance of freshwater mussels as indicated by muskrat predation during December 1990–March 1991 at Collection Station 46. Area sampled consisted of a 67.5 m stretch of beach/shallows near the former confluence of Ninemile Creek and the Little Tennessee River.

Species	Date collected			
	4 Jan.	3 Feb.	2 Mar.	5 Apr.
<i>Anodonta grandis</i>	6	1	2	5
<i>Anodonta imbecillis</i>	2	1	1	1
<i>Lasmigona complanata</i>	12	11	7	4
<i>Leptodea fragilis</i>	1	—	1	—
<i>Obliquaria reflexa</i>	181	106	59	47
<i>Potamilus alatus</i>	1	1	1	2
<i>Potamilus ohiensis</i>	12	22	20	19
Totals	215	142	91	78

distributed in Tellico Lake, followed by *P. alatus* (found at 18 collection stations) and *L. fragilis* (12 collection stations). These species often become abundant in shallow river embayments and lakes, and in all probability all three are considerably more numerous in Tellico Lake than they were in the Little Tennessee River.

*Obliquaria reflexa* Rafinesque, 1820, a species typical of medium-sized to large rivers, can adapt to and flourish in lake environments. In the initial study of the unionids of Lake Springfield in central Illinois (Parmalee, 1955), this species was not encountered, but approximately 20 years later it was second in abundance only to *Quadrula quadrula* (Rafinesque, 1820) (Klippel and Parmalee, 1979). *Obliquaria reflexa* occurs throughout Tellico Lake and is locally abundant. Age estimates of large mature specimens, based on rest lines in the periostracum, suggest that this mussel became established in the reservoir within two years of filling. Isom (1971) did not encounter this mussel during his survey of Fort Loudoun Lake, but it has been observed and collected there by us and others during the past four to five years. Fort Loudoun Lake is probably the source from which the Tellico Lake populations derived.

From January 4 through April 5, 1991, shells left by muskrats were collected among a 67.5 m stretch of beach and shallows at Ninemile Creek (Collection Station 46). The collections resulted from muskrat predation over approximately a four-month period as the initial collection included individuals from December and possibly late November, 1990. A total of 526 specimens was recovered (Table 3), of which 393 (75%) were *O. reflexa*. A decline in the number of mussels taken by muskrats from mid-winter to early spring is apparent in the case of *O. reflexa*. Probably heavy predation on this bed was a contributing factor in the decline of individuals of at least this species during the winter.

The distribution of *Quadrula pustulosa* (Lea, 1831) appears to be restricted to the lower portion of the reservoir near Tellico Dam. Only four specimens were recovered (Collection Stations 1, 9, 10). Although the two largest individuals exhibit eight distinct rest lines on the periostracum, suggesting their presence three to four years after formation of the lake, a viable population has not become established.

Although *Q. pustulosa* appears to be relatively uncommon in upper Watts Bar Lake below Fort Loudoun Dam (Tennessee River (TR) km 944) (Ahlstedt, 1989), it is locally abundant in lower sections of the reservoir. For example, a collection



from an approximately 180 m long by 18 m wide stretch of beach at Fooshee Pass Recreation Area, Meigs County (TR km 861), included 545 specimens representing five species. Eighty-three percent were *Q. pustulosa*. Of the six species of fish recorded by Fuller (1974) as hosts for the glochidia of *Q. pustulosa*, at least four (channel catfish, *Ictalurus punctatus*; black bullhead, *Ictalurus melas*; flathead catfish, *Pylodictus olivaris*; white crappie, *Pomoxis annularis*) are common throughout the reservoir. Why viable populations of *Q. pustulosa* have failed to become established in the Tellico and Fort Loudoun reservoirs is unknown.

*Villosa vanuxemensis* was represented in the Tellico Lake collection by a single mature (61.0 × 35.2 × 31.0 mm) relict female found on the beach at Collection Station 13. Prior to impoundment this area would have been adjacent to Poplar Springs, a small tributary creek of the Little Tennessee River. This mussel is characteristic of small creeks and headwaters of larger streams in eastern Tennessee and probably inhabited the small tributaries of the Little Tennessee River prior to impoundment. Inadvertently, it was not listed by Starnes and Bogan (1988) as a component of the Little Tennessee River mussel assemblage. Parmalee and Klippel (1984) found that *V. vanuxemensis* was the most abundant mussel in the Tellico River, the major tributary of the Little Tennessee River.

In recent years numerous studies on mussel species diversity and abundance as they relate to potential commercial harvesting and existing ecological conditions (Williams, 1969; Yokley, 1972; Gooch et al., 1979), causes of mortality (Neves, 1987), the location and protection of rare and endangered taxa, and the impact of proposed industrial development (Ahlstedt, 1989) have appeared. Such investigations are essential if freshwater mussels in the Tennessee River, and in other rivers and lakes, are to be protected. In the past, molluscan faunas occurring in newly formed reservoirs, and those which existed in the free-flowing Tennessee River prior to impoundment, often were not evaluated or compared until decades later. Moreover, only limited stretches or local areas, such as Muscle Shoals, Alabama (Stansbery, 1964), have been monitored in detail. Tellico Lake, however, provides an opportunity to compare the mussel assemblage of the Little Tennessee River with one that has invaded and is becoming established in the recently formed reservoir.

The invasion and establishment of mussel taxa in Tellico Lake reflects a pattern typical of other well-established reservoirs in the Tennessee River system. With few exceptions, mussel species that flourished in shoals and riffles of the free-flowing Tennessee River disappeared with impoundment, or surviving taxa were reduced to non-reproducing relict individuals. Although most Tennessee River reservoirs retain strong currents in the old channels and below the dams, constant change in rates of flow and depth, insufficient dissolved oxygen, and continuing deposition of sediment have adversely affected mussel reproduction and actual survival of species (van der Schalie, 1938; Isom, 1969, 1971).

Extensive shallows (<1.5 m depths) along beaches in coves and embayments lacking current presently provide the most suitable mussel habitat and support the greatest number of individuals and taxa in Tellico Lake. Bank run-off and wave action cause erosion that results in a substrate mixture of sand, mud and fine gravel in these shallow areas. Nine of the 14 mussel species inhabiting the reservoir are silt tolerant and typically reach greatest abundance in such habitats. The occurrence of species requiring moderate to strong current and a stable substrate would not be expected in a lake environment, yet a few such as *Obliquaria reflexa* can adapt and thrive in lakes. Recovery of only one single juvenile specimen



of *Elliptio crassidens* from Tellico Lake suggests that this species, which is locally common in the main channel of the Tennessee River, failed to become established in this reservoir.

#### SUMMARY

Collections of freshwater mussels made during the period November, 1990, through March, 1991, in Tellico Lake, Loudon and Monroe counties, Tennessee, included specimens of 14 native unionid taxa and the Asian clam, *Corbicula fluminea*. The diverse assemblage of naiad species (50) once inhabiting the Little Tennessee River has been reduced in Tellico Lake to six taxa (*Anodonta grandis*, *Elliptio crassidens*, *Quadrula pustulosa*, *Leptodea fragilis*, *Potamilus alatus*, and *Potamilus ohioensis*). Eight species previously unreported from the river and assumed to be of recent origin include *Anodonta imbecillis*, *Anodonta suborbiculata*, *Lasmigona complanata*, *Obliquaria reflexa*, *Toxolasma parvus*, *Truncilla donaciformis*, *Truncilla truncata*, and *Villosa vanuxemensis*. The latter three species, as well as *Q. pustulosa* and *E. crassidens*, were each represented by fewer than six specimens. The paucity of individuals of these five taxa suggests the occasional establishment of one or a few individuals from parasitized fish, or in the case of *V. vanuxemensis* a possible pre-impoundment relict for which this reservoir lacks suitable habitat for establishment of viable populations. An abundance of shallow coves and embayments characterized by a sand/mud/silt substrate in Tellico Lake have allowed the establishment and rapid increase of several species of *Anodonta* and *Potamilus* throughout the reservoir.

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